unit were used in a series of science missions conducted with the Altair uninhabited air vehicle, providing the first indication that used together, the two technologies would be a winning combination. The mission series also marked the first UAV collaboration between Dryden and the National Oceanic and Atmospheric Administration.

Dryden assisted NOAA with lease of the Altair aircraft, owned and built by General Atomics Aeronautical Systems Inc. of San Diego, and provided support for a series of atmospheric and oceanic research flights off the California coastline.

Whether using an actual UAV or a surrogate like the ER-2, the next step in development is being carried out by NASA's Earth Science Capabilities Demonstrations project. The ESCD targets development of technologies that will improve UAV capabilities for use in Earth observation.

Future Earth science UAVs, Freudinger said, will essentially be used as scouts. Just as when any other scout might be sent on a mission, productive use of time is a combination of decision-making by the scout and communication between the scout and others when some objective is either met or not met. In addition to weather phenomena, for example, these instrumented UAVs could enable humans to keep watch on the health of Emperor penguins in the Antarctic. The penguins' role as a relatively small population near the top of the food chain in the cold and icy Antarctic suggest that their health as a species could be an indicator of global climate change.

Scouting with UAVs will demand one or more forms of communication capable of reacting to changing circumstances. The value of the airborne sensor-web concept, says Freudinger, is in gaining better and more flexible remote-scouting capabilities that are adaptable to change. In the future, sensor webs being flown for weeks or months aboard long-endurance UAVs will contact researchers when something interesting is located. The REVEAL and RBNB technologies are among the types of tools that will be needed to build this capability.

Origins

Earth science was not the application Freudinger envisioned when the SBIR program began to deliver for him more than a decade ago.

In 1992, while trying to solve an unrelated problem in aeronautical flight research, he saw the possibilities offered by SBIR grants. He saw the program as a way for researchers to fund the speculative research work necessary to remove technology barriers and create new ways of conducting the business of flight research.

"It's kind of like going fishing," he said. "You set up a (contract solicitation) subtopic to lure solutions to your problems and wait to see what comes in. "You get all these nibbles, and you pick the best."

In this case, the subtopic was a broadly defined abstract for automated and online data reduction, and the proposal by Creare Inc. was for something called a "practical real-time wavelet signal analyzer."

"Along the way we discovered that Creare's software had some unique features we didn't see anywhere else," Freudinger recalled. "Through a subsequent proposal the NASA/Creare team worked to generalize those features to enable data reduction through network computing on aircraft such as an F-18. The result was RBNB DataTurbine."

SBIR as catalyst

Getting a revolutionary idea funded and finding projects on which to test the idea can be a challenge. In Freudinger's case, he knew network computing was the technology direction he wanted to pursue but finding the money just to get started was a real stumbling block. New test techniques can take years to mature, and bureaucratic planning processes "can truncate efforts to engage in truly visionary work," he said. An SBIR grant proved to be a handy tool for filling a funding gap for technologies like Freudinger's, considered too premature for large-scale investment.

Proposals for NASA SBIR contracts are generally solicited through application area subtopics. Freudinger took advantage of the flexibility offered by the SBIR program and wrote a new SBIR subtopic to solicit ideas for on-line health management and automated data analysis.

Researchers who find themselves in the same situation he faced with RBNB should "go talk to SBIR program managers," Freudinger said. "They're eager to pave the way."

Because the RBNB DataTurbine is useful for managing continuously changing information needed for making rapid decisions, it has value beyond its initial focus. Constructed as a solution for needs in aeronautical flight-testing, it can be used in applications ranging from Homeland Security and disaster relief efforts to networked security cameras, medical monitoring and online gaming.

The hands of innovative researchers struggling today with tomorrow's challenges are supplying the technology pipeline with solutions and opportunities. When it comes to solving problems, NASA's SBIR program is a proven tool.

Just the facts

Visit the SBIR Web site:
http://sbir.nasa.gov

Hurricane mission:
http://tcsp.msfc.nasa.gov

RBNB information:
http://rbnb.creare.com

For more information:
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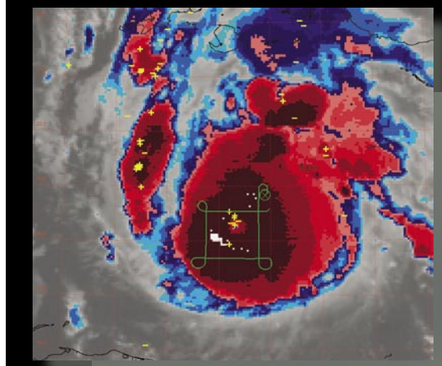
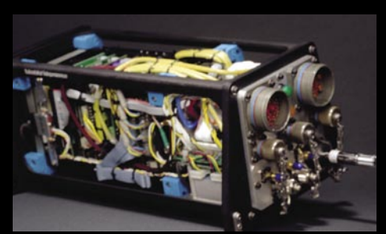


Technology Triumph

NASA Photo by Bill Ingalls

NASA SBIR contracts are playing key roles in the creation of versatile research tools to enable development of a global-reach Earth observation system that can even analyze hurricanes. How can the SBIR program support your ideas?



NASA Photo by Tom Tschida

Sharpening the cutting edge

SBIR contracts assist researchers in knocking down complex technology barriers

By Jay Levine
X-Press Editor

Dryden ER-2 pilot David Wright flew near the wall of the eye of Hurricane Emily on July 17 as she moved across the Caribbean toward Mexico's Yucatan Peninsula. It was a rough flight and it appeared that it was about to get a lot rougher.

During the eight-hour flight Wright collected information about Emily, a storm that caused extensive damage in the Yucatan. Just a week earlier he had flown the ER-2 in similar experiments over Hurricane Dennis.

"Hurricane Dennis was much kinder," said Wright following the July 17 flight. "Emily just didn't want me around."

Wright was part of a team comprised of scientists, engineers and technicians from Dryden, four other NASA centers and 10 American universities. Manning the Tropical Cloud Systems and Processes mission, personnel were stationed in San Jose, Costa Rica in July to study how tropical storms become hurricanes. Researchers from the National Oceanic and Atmospheric Administration and the Costa Rican Centro Nacional de Alta Tecnologia also were part of the mission team.

Team members conducted ground and air studies to measure the buildup and behavior of tropical storm systems, collecting detailed weather information as the storms grew or subsided. They were aided in their work by technologies that permitted collection and delivery of data from the aircraft to researchers on the ground in near-real time. Key technologies used in the mission got their start from NASA's Small Business Innovation Research, or SBIR program.

For example, a software program called the Ring Buffer Network Bus – or RBNB DataTurbine™, its commercial moniker – made it easier for researchers on the ground to capture and process live data streams coming from the ER-2 aircraft while making the data available for viewing with Internet Web browsers. The DataTurbine program allowed the mission ground crew to remain apprised of aircraft and onboard instrument status.

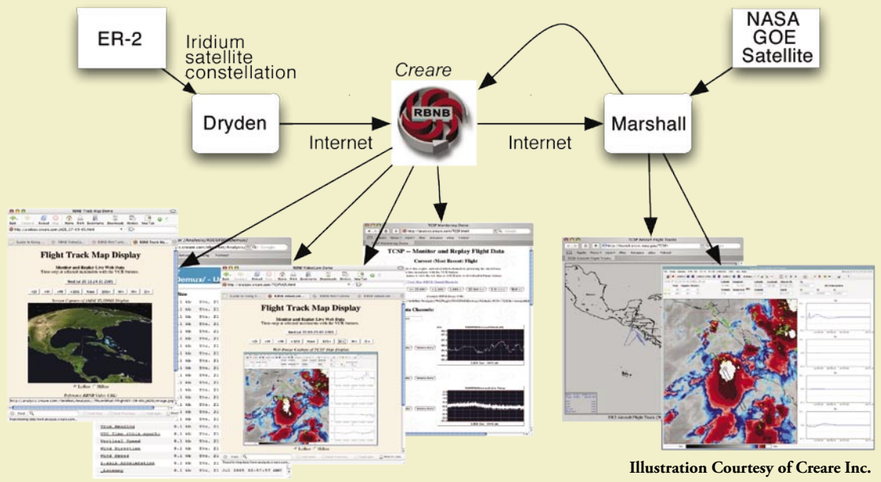


Illustration Courtesy of Creare Inc.

The X-tra cover shows Dryden's ER-2 as it departed San Jose, Costa Rica on a mission to monitor tropical storms and the formation of hurricanes. The cover's inset image shows the path taken by the ER-2 over Hurricane Emily as scientists on the ground viewed storm data generated in near-real time. The REVEAL instrument, pictured at bottom right on the cover, is the hardware that provides the gateway through which researchers kept tabs on the aircraft while interacting with instrumentation. Using RBNB DataTurbine™ software to manage data enabled researchers to easily integrate several displays and analysis tools with data from a variety of sources, some of which are represented in the illustration above.

For the flight over Hurricane Emily, the software was used to keep Wright and the ER-2 a safe distance from the wall of the hurricane's eye. Knowing the aircraft's location at all times in relation to the storm enabled the team on the ground to optimize flight routes for obtaining desired data in spite of the storm's unpredictable nature.

SBIR sparks success

About a decade ago a NASA SBIR project sparked the idea for the network-distributed signal processing that became the RBNB technology. NASA's research partner was Creare Inc. of Hanover, N.H. So innovative was the idea that the RBNB software was nominated for the Agency's 1999 Software of the Year award. In 2000, it was recognized by R&D magazine, a publication devoted to technology innovations, as one of the year's most significant new developments.

An SBIR contract enables government researchers to find small business partners with common technology-development interests. Two phases of competition for SBIR funding provide up to $670,000 for use in breaching technology barriers and developing prototype solutions to address needs described in grant solicitations.

In the case of RBNB, researchers wanted to "disconnect," or separate, live data generated by sensor instruments from the applications that process or display the data. This disconnection effectively separates the acquisition, storage, distribution and processing of data test and measurement (and problems inherent in those processes). Researchers then have greater flexibility in identifying solutions because components are distributed and accessible across a network. The RBNB software might be thought of as a network of TiVo™ boxes – consumer television hardware that permits simultaneous viewing and recording of programs – for test data instead of television shows.

Such a network "enables you to make the best possible use of the time you have available," explained Larry Freudinger, Dryden's lead researcher for airborne sensor-web systems. Sensor webs are networks of automated instruments.

"The RBNB software makes it easy and inexpensive to build the time-sensitive information systems that are required for managing continuously changing data from multiple sources."

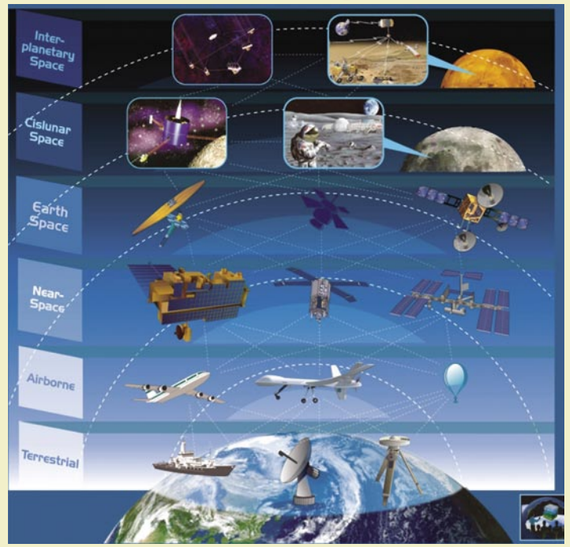
Changing the rules

DataTurbine technology is changing the way mission planners think about how to execute research. In the past, for example, data gathered during research flights was typically recorded for later use or went solely to a lone control room during a mission. Now, that information can be sent to a network and ultimately fed to partners all over the globe. The ER-2 aircraft's recent storm-tracking missions in Costa Rica offered a glimpse of the potential for global test-range capabilities, where resources and researchers are distributed across the planet.

Freudinger and his team's contributions extend beyond the RBNB DataTurbine.

Whereas the RBNB software was built for use in airborne networks, there weren't any data-acquisition systems yet built that were designed to live on a network.

"We saw the test and measurement industry evolving toward sensor webs, but we didn't see any tools for researching hard problems associated with networks of data-acquisition systems embedded in things like airplanes," Freudinger said. "So we built one."



NASA Illustration by Jenny Mottar

This artist's conception shows a future system-of-systems for observation and exploration of Earth and beyond. Tools like REVEAL hardware and RBNB software represent pieces of the technology puzzle that will enable this future system to become a reality. NASA's SBIR grant program provides researchers and small businesses with the seed money necessary to feed the pipeline of innovation that helps NASA and industry achieve their goals.

That tool is called the Research Environment for Vehicle-Embedded Analysis on Linux, or REVEAL. Conceived five years ago as "an aircraft in a box" for sensor-web research, the REVEAL unit evolved into a programmable gateway between the onboard instruments and wireless communication paths to and from aircraft. Built with an internal sensor suite and its own data-acquisition capabilities, a REVEAL unit on board the ER-2 provided, via RBNB, the data needed for near-real time displays. It also enabled interactive communications between researchers and a lightning instrument package installed on ER-2, allowing researchers to safely query instrument status and monitor the storm's electrical characteristics.

"The value of REVEAL is in the software," said Freudinger. "We spent plenty of time thinking about problems involved in managing a reconfigurable data-acquisition system flying on some remote aircraft, and the performance and flexibility of REVEAL is a reflection of time well spent."

Designed and built in conformance with open-source software specifications, REVEAL was nominated for NASA's Software of the Year award in 2004.

The Costa Rica mission also illustrated the potential of using the RBNB DataTurbine and the REVEAL unit in tandem.

"The ER-2 was based in Costa Rica," said Freudinger. "It would take off and fly around hurricanes and tropical storms down in Central America. Status information would go automatically from the airplane through the Iridium satellite constellation, drop down to the planet, in Arizona, and then go over the phone lines to our lab (at Dryden). Then the data would get on the network and go to New Hampshire, which is where our primary RBNB server is located. The data packets were captured and reformatted, making them immediately available (on the Web) for analysis and display."

Users could access the Creare Web site or a site at NASA's Marshall Space Flight Center in Huntsville, Ala., to obtain maps and graphs of measurements only a second or two old. Automated software monitored parameters for conditions of interest, sending out email alerts to record interesting observations.

"What we are building is a sustainable capability for a global network of Earth-observation instruments," Freudinger said. "Over time, these instrument networks become increasingly autonomous and productive without the cost of ownership and operation getting excessive."

UAV Science missions coup

In May, just prior to the ER-2 mission, the DataTurbine software and a REVEAL

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